

(19) 日本国特許庁 (JP)

(12) 公開特許公報 (A)

(11) 特許出願公開番号

特開平9-73133

(43) 公開日 平成9年(1997)3月18日

(51) Int.Cl.*	識別記号	序内整理番号	F I	技術表示箇所
	G 03 B 21/62		G 03 B 21/62	
	21/56		21/58	Z
	G 03 H 1/22		G 03 H 1/22	

審査請求 未請求 請求項の数 8 FD (全 7 頁)

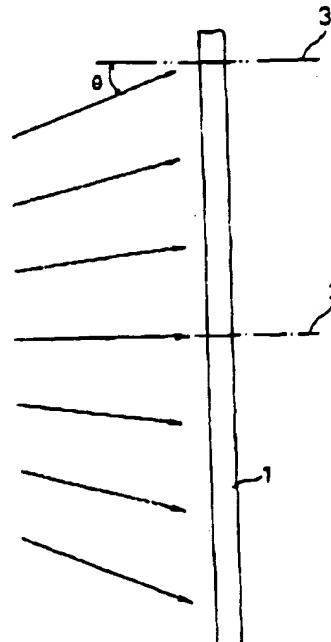
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Jap. Pat. OPI No. 9-73133 (3-18-97)			
Jap. Pat. Appln. No. 7-250056 (9-5-95)			
Applicant: CASIO COMPUT CO LTD			

(54) 【発明の名称】 透過型スクリーン

(57) 【要約】

【課題】 光の利用効率が良く、鮮明な投影画像が得られるようにする。

【解決手段】 光軸2に対して広がり角度をもった投影光をスクリーンの辺線3方向に変換させるホログラム1を備えた。このホログラム1は、半径方向に特性を有する波長選択性がないか若しくは少ないもので、1つの回折格子で投影光のいずれの波長も回折し、かつ波長に応じて異なる回折角で回折するものである。したがって、拡散フィルムなどの拡散板を用いなくても、光軸2に対して広がり角度をもった投影光を損失することなく良好にスクリーンの辺線3方向に変換させて出射させることができ、このため光の利用効率が良く、鮮明な投影画像を得ることができる。



1
【特許請求の範囲】

【請求項1】 広がり角度をもった投影光をスクリーンの法線方向に変換させるホログラムを備えたことを特徴とする透過型スクリーン。

【請求項2】 前記ホログラムは、半径方向に異なる特性を有する波長選択性がないか若しくは少ないものであることを特徴とする請求項1記載の透過型スクリーン。

【請求項3】 前記ホログラムは、半径方向に異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた構造であることを特徴とする請求項1記載の透過型スクリーン。

【請求項4】 前記ホログラムは、中心から短辺方向では垂直方向だけに異なる特性を有する波長選択性がないか若しくは少ない第1ホログラムと、前記中心から長辺方向では水平方向だけに異なる特性を有する波長選択性がないか若しくは少ない第2ホログラムとを重ね合わせた構造であることを特徴とする請求項1記載の透過型スクリーン。

【請求項5】 前記ホログラムは、中心から短辺方向では垂直方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第1ホログラム群と、前記中心から長辺方向では水平方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第2ホログラム群とを重ね合わせた構造であることを特徴とする請求項1記載の透過型スクリーン。

【請求項6】 前記ホログラムは、半径方向に全体傾向としては異なる特性を有して前記投影光をスクリーンの法線方向に変換し、微細エリアとしては1点集光または線集光の特性を有するものであることを特徴とする請求項1記載の透過型スクリーン。

【請求項7】 広がり角度をもった投影光を平行光線に変換する光学素子と、この光学素子から出射されて一定方向の入射角度で入射した光線をスクリーンの法線方向に分光集光するホログラムとを備えたことを特徴とする透過型スクリーン。

【請求項8】 前記光学素子は、フレネルレンズ、またはフレネルレンズとリニアプリズムレンズの組み合わせであることを特徴とする請求項7記載の透過型スクリーン。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 この発明は透過型スクリーンに関する。

【0002】

【従来の技術】 投影レンズによって画像が投影されるスクリーンには、投影された画像を投影レンズ側から観察する反射型スクリーンと、投影された画像を投影レンズと反対側から観察する透過型スクリーンとがあり、ここ

では透過型スクリーンについて説明する。この透過型スクリーンは、一般に、拡散フィルムなどの拡散板からなり、この拡散板に投影レンズから広がり角度をもった投影光を入射させ、この入射した光を拡散板によって拡散させて出射する構造になっている。

【0003】

【発明が解決しようとする課題】 しかしながら、このような透過型スクリーンでは、拡散板の透過率を高くすると拡散性が低下し、逆に拡散性を高くすると透過率が低下するため、光の損失があり、鮮明な投影画像が得られないという問題がある。この発明の課題は、光の利用効率が良く、鮮明な投影画像を得ることができるようにすることである。

【0004】

【課題を解決するための手段】 請求項1記載の発明は、広がり角度をもった投影光をスクリーンの法線方向に変換させるホログラムを備えたから、拡散フィルムなどの拡散板を用いなくても、広がり角度をもった投影光を損失することなく良好にスクリーンの法線方向に変換させて出射させることができ、このため光の利用効率が良く、鮮明な投影画像が得られる。

【0005】 この場合、請求項2に記載のごとく、ホログラムが半径方向に異なる特性を有する波長選択性がないか若しくは少ないものであれば、投影光を各波長成分ごとに分光してスクリーンの法線方向に変換することができ、また請求項3に記載のごとく、ホログラムが半径方向に異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた構造であれば、広がり角度をもった投影光を赤、緑、青の各波長成分ごとに分光してスクリーンの法線方向に出射させることができる。

【0006】 また、請求項4に記載のごとく、ホログラムが、中心から短辺方向では垂直方向だけに異なる特性を有する波長選択性がないか、若しくは少ない第1ホログラムと、中心から長辺方向では水平方向だけに異なる特性を有する波長選択性がないか、若しくは少ない第2ホログラムとを重ね合わせた構造、または請求項5に記載のごとく、ホログラムが、中心から短辺方向では垂直方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第1ホログラム群と、中心から長辺方向では水平方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第2ホログラム群とを重ね合わせた構造であれば、広がり角度をもった投影光を各波長成分ごとに分光した上それぞれ水平方向および垂直方向に変換して出射させることができる。

【0007】 さらに、請求項6に記載のごとく、ホログラムが、半径方向に全体傾向としては異なる特性を有して投影光をスクリーンの法線方向に変換し、微細エリア

としては1点集光または線集光の特性を有するものであれば、広がり角度をもった投影光を全体傾向として各波長成分に分光し、かつ分光した光を微細エリアでマイクロレンズのように集光させることができる。

【0008】請求項7記載の発明は、広がり角度をもった投影光を平行光線に変換する光学素子と、この光学素子から出射されて一定方向の入射角度で入射した光線をスクリーンの法線方向に分光集光するホログラムとを備えたから、光学素子により広がり角度をもった投影光を平行光線に変換してホログラムに入射させることができ、かつホログラムにより入射した光を損失することなくスクリーンの法線方向に分光集光させることができ、このため光の利用効率が良く、鮮明な投影画像が得られる。

【0009】この場合、請求項8に記載のごとく、光学素子がフレネルレンズであれば、広がり角度をもった投影光をホログラムにほぼ垂直に入射させることができ、また光学素子がフレネルレンズとリニアプリズムレンズの組み合わせであれば、フレネルレンズにより投影光をホログラムに対するほぼ垂直方向に変換し、この変換された光をリニアプリズムレンズにより一定方向の入射角度でホログラムに入射させ、この入射した光をホログラムによりスクリーンの法線方向に変換させることができる。

【0010】

【発明の実施の形態】

【第1実施形態】以下、図1～図4を参照して、この発明に係わる透過型スクリーンの第1実施形態について説明する。図1は透過型スクリーンの斜視図であり、図2はそのA-A断面図である。この透過型スクリーンは、ホログラム1からなり、投影レンズ系などによって投影される投影光が光軸2に対し広がり角度をもって入射するものである。このホログラム1は、半径方向に異なる特性を有する波長選択性がないか、若しくは少ないものであり、1つの回折格子で投影光のいずれの波長も回折するとともに、波長に応じて異なる回折角で回折し、広がり角度をもった投影光をスクリーンの法線方向に変換して出射する構造になっている。例えば、このホログラム1は、回折格子がホログラム1の中心つまり光軸2の位置を中心とする同心円状に形成され、1つの回折格子が、図3に示す原理図のように、投影光を赤、緑、青の3種類の波長成分に分光してスクリーンの法線方向に向けて出射する構造になっている。なお、図3の原理図では法線方向よりも中心側（光軸2側）に向けて出射しているが、実際にはほぼ法線方向に向けて出射する。

【0011】すなわち、このホログラム1に入射する光の入射角とホログラム1との関係は、スクリーン（ホログラム1）の法線3に対する入射角をθ、ホログラム1からの光の出射角のうち、赤波長成分の光の出射角をψa、緑波長成分の光の出射角をψc、青波長成分の光の出

射角をψb、赤、緑、青の各波長をλa、λc、λb、ホログラム1の回折格子のピッチをdとしたとき、

$$\sin \theta + \sin \psi a = \lambda a / d \quad \dots \dots \dots (1)$$

$$\sin \theta + \sin \psi c = \lambda c / d \quad \dots \dots \dots (2)$$

$$\sin \theta + \sin \psi b = \lambda b / d \quad \dots \dots \dots (3)$$

の各条件を満足している。また、このホログラム1の特性は、図4に示すように、ホログラム1の中心（光軸2の位置）から半径方向の距離sが長くなるに従って、回折格子のピッチdが次第に小さくなるように設定されている。したがって、このホログラム1では、入射角θで入射した光が赤、緑、青の各波長成分に分光され、分光された各波長成分の光λa、λc、λbをそれぞれ異なる出射角ψa、ψc、ψbでホログラム1のほぼ法線方向に出射する。また、このホログラム1は、入射角θが大きい外周側では各波長成分の光の出射角ψa、ψc、ψbが大きく、逆に入射角θが小さい光軸2の付近では各波長成分の光の出射角ψa、ψc、ψbが小さくなる。

【0012】このような透過型スクリーンでは、広がり角度をもった投影光がホログラム1に入射すると、図3に示す原理図のように、投影光が赤、緑、青の各波長成分に分光されるとともに、分光された各波長成分の光がスクリーン（ホログラム1）のほぼ法線方向に向けて出射される。このときには、図4に示すように、ホログラム1の中心（光軸2）から半径方向の距離sが長くなるに従って、回折格子のピッチdが次第に小さくなるように設定されているので、入射角θが大きい外周側では各波長成分の光の出射角ψa、ψc、ψbが大きく、逆に入射角θが小さい光軸付近では各波長成分の光の出射角ψa、ψc、ψbが小さくなり、これにより各波長成分の光がスクリーン（ホログラム1）のほぼ法線方向に向けて出射されることになる。したがって、従来のように拡散フィルムなどの拡散板を用いなくても、広がり角度をもった投影光をホログラム1によって損失することなく良好にスクリーンの法線方向に変換させて出射させることができ、このため光の利用効率が良く、鮮明な投影画像を得ることができる。

【0013】なお、上記第1実施形態では、半径方向に異なる特性を有する波長選択性がないか、若しくは少ないホログラム1を用いたが、これに限らず、例えばホログラムが半径方向に異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた構造であってもよい。このようにすれば、投影光を各波長成分に応じて回折する各ホログラムによってそれぞれ赤、緑、青の各波長成分ごとに分光してスクリーンの法線方向に出射させることができるので、これによっても、投影光を損失することなく出射させることができ、このため光の利用効率が良く、鮮明な投影画像を得ることができる。

【0014】また、上記第1実施形態では、ホログラム1の1つの回折格子を単純な円形状に形成したが、これ

に限らず、1つの回折格子をギザギザな円形状に形成し、これを同心円状に配列形成することにより、半径方向に全体傾向としては異なる特性を有して前記投影光をスクリーンの法線方向に変換し、微細エリアとしては1点集光または線集光の特性を有する構造のホログラムでもよい。このホログラムの回折格子のピッチ δ は、第1実施形態と同様、中心（光軸）から半径方向への距離が長くなるに従って次第に小さくなるように設定されている。このようになホログラムの特性は、図5に示すように、左上から右下に向けて全体的に緩やかな曲線になっているが、この曲線がギザギザな形状になる特性を有している。このようなホログラムを用いても、広がり角度をもった投影光を全体傾向として各波長成分に分光し、かつ分光した光をギザギザな微細エリアでマイクロレンズのように集光させることができ、このため投影光を損失することなくスクリーンの法線方向に向けて出射することができるので、光の利用効率が良く、鮮明な投影画像を得ることができる。

〔0015〕〔第2実施形態〕次に、図6および図7を参照して、この発明に係わる透過型スクリーンの第2実施形態について説明する。この透過型スクリーンは、図6および図7に示すように、第1ホログラム11と第2ホログラム12を重ね合わせた構造のホログラム10からなり、投影レンズ系によって投影される投影光がホログラム10に広がり角度もって入射する構造になっている。

〔0016〕第1ホログラム11は、その中心（光軸13）から短辺方向（上下方向）において垂直方向だけに異なる特性を有する波長選択性がないか、若しくは少ないものである。すなわち、この第1ホログラム11は、1つの回折格子で投影光のいずれの波長も回折するとともに、各波長に応じて異なる回折角で回折するものであり、第1実施形態とは異なり、回折格子が長辺に沿う水平方向に延び、上下方向に所定ピッチ δ で配列形成され、広がり角度をもって入射した投影光のうち、垂直方向に広がる光をほぼ水平方向（法線14方向）に変換する構造になっている。例えば、この第1ホログラム11は、1つの回折格子で赤、緑、青の各波長成分に分光するとともに、光軸13から上下方向への距離が長くなるに従って、回折格子のピッチ δ が次第に小さくなるように設定され、これにより入射角 θ が小さい光軸13付近では各波長成分の光の出射角 ϕ_R 、 ϕ_G 、 ϕ_B が小さく、入射角 θ が大きい上下辺側では各波長成分の光の出射角 ϕ_R 、 ϕ_G 、 ϕ_B が大きくなるように構成されている。

〔0017〕また、第2ホログラム12は、その中心（光軸13）から長辺方向（左右方向）において水平方向だけに異なる特性を有する波長選択性がないか、若しくは少ないものである。すなわち、この第2ホログラム12は、第1ホログラム11と同様、1つの回折格子で投影光のいずれの波長も回折するとともに、波長に応じ

て異なる回折角で回折するものであり、第1ホログラム11とは異なり、回折格子が短辺に沿う垂直方向に延び、左右方向に所定ピッチ δ で配列形成され、広がり角度をもって入射した投影光のうち、水平方向に広がる光をほぼ法線14方向に変換する構造になっている。例えば、この第2ホログラム12は、1つの回折格子で赤、緑、青の各波長成分に分光するとともに、光軸13から左右方向への距離が長くなるに従って、回折格子のピッチ δ が次第に小さくなるように設定され、これにより入射角 θ が小さい光軸13付近では各波長成分の光の出射角 ϕ_R 、 ϕ_G 、 ϕ_B が小さく、入射角 θ が大きい左右辺側では各波長成分の光の出射角 ϕ_R 、 ϕ_G 、 ϕ_B が大きくなるように構成されている。

〔0018〕このような透過型スクリーンでは、光軸13に対して広がり角度もった投影光が第1ホログラム11に入射すると、この第1ホログラム11によって上下方向（垂直方向）に広がる投影光を赤、緑、青の各波長成分に分光してスクリーンの法線方向（水平方向）に向けて出射し、水平方向に広がる投影光はそのまま第1ホログラム11を通過する。そして、第1ホログラム11を通過した投影光が第2ホログラム12に入射すると、この第2ホログラム12によって左右方向（水平方向）に広がる投影光を赤、緑、青の各波長成分に分光してスクリーンの法線方向に向けて出射し、上下方向（垂直方向）の投影光はそのまま第2ホログラム12を通過する。したがって、ホログラム10に入射した広がり角度をもった投影光は、第1ホログラム11および第2ホログラム12によって赤、緑、青の各波長成分に分光された上、水平方向および垂直方向に変換されてスクリーンの法線方向に出射されるので、第1実施形態と同様、広がり角度をもった投影光を損失することなく良好にスクリーンの法線方向に出射させることができ、このため光の利用効率が良く、鮮明な投影画像を得ることができる。

〔0019〕なお、上記第2実施形態では、中心（光軸13）から短辺方向では垂直方向だけに異なる特性を有する波長選択性がないか若しくは少ない第1ホログラム11と、中心（光軸13）から長辺方向では水平方向だけに異なる特性を有する波長選択性がないか若しくは少ない第2ホログラム12とを重ね合わせた構造のホログラム10を用いたが、これに限らず、例えば中心から短辺方向では垂直方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第1ホログラム群と、中心から長辺方向では水平方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第2ホログラム群とを重ね合わせた構造のホログラムでもよい。このようにしても、第1ホログラム群と第2ホログラム群とによって投影光を赤、緑、青の各波長成分ごとに分光した上それぞれ水平方向

および垂直方向に変換してスクリーンの法線方向に向けて出射させることができ、これによても、投影光を損失することなく出射させることができるので、光の利用効率が良く、鮮明な投影画像を得ることができる。

[0020] [第3実施形態] 次に、図8および図9を参照して、この発明に係わる透過型スクリーンの第3実施形態について説明する。なお、図1～図4に示された第1実施形態と同一部分には同一符号を付し、その説明は省略する。この透過型スクリーンは、図8および図9に示すように、ホログラム1と拡散レンチ20とからなり、光軸2に対して広がり角度をもった投影光の入射側にホログラム1が配置され、出射側に拡散レンチ20が配置された構造になっている。この場合、ホログラム1は第1実施形態とまったく同様に構成されている。拡散レンチ20は、透明な樹脂フィルムまたは透明な樹脂ボードなどからなり、その出射面にレンチキュラレンズ21を水平方向に配列形成したものであり、このレンチキュラレンズ21で水平方向に広がる赤、緑、青の各波長成分の光を集光する構造になっている。

[0021] このような透過型スクリーンでは、広がり角度をもった投影光がホログラム1に入射すると、このホログラム1によって投影光を赤、緑、青の各波長成分に分光し、分光した各波長成分の光をスクリーンの法線3方向に変換して出射し、この出射された光が拡散レンチ20に入射し、この拡散レンチ20のレンチキュラレンズ21によって赤、緑、青の各波長成分に分光された光のうち水平方向に広がる光を集光する。このため、第1実施形態と同様、広がり角度をもった投影光線をホログラム1でスクリーンの法線方向に変換するので、光を損失することなく投影光線をスクリーンの法線方向に出射することができるほか、特にホログラム1から出射された光のうち水平方向に広がる光を拡散レンチ20で集光するので、投影光に視野角をもたせることができ、このため視野角特性の向上が図れる。

[0022] なお、上記第3実施形態では、レンチキュラレンズ21を拡散レンチ20の出射面に水平方向に配列形成したが、これに限らず、レンチキュラレンズ21を垂直方向に配列形成して、上下方向に広がる光を集光させるようにしてもよい。また、上記第3実施形態では、レンチキュラレンズ21を有する拡散レンチ20を用いたが、これに限らず、拡散フィルムなどの拡散板を用いてもよい。この場合には、ホログラム1で投影光をスクリーンの法線方向に変換しているので、拡散板は拡散性を低く抑えた透過率の高いものを用いることができる。このため、このような拡散板を用いた場合には、透過率が高いため、その出射面に第3実施形態と同様にレンチキュラレンズを形成しても光の損失が少ない。

[0023] また、上記第3実施形態では、第1実施形態とまったく同じ構造のホログラム1を用いた場合について述べたが、これに限らず、例えば、半径方向に異なる

特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた構造のホログラム、または第2実施形態と同じ構造のホログラム10、あるいは中心から短辺方向では垂直方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第1ホログラム群と、中心から長辺方向では水平方向だけに異なる特性を有し、赤、緑、青の各波長成分ごとの波長選択性のある3種類のホログラムを重ね合わせた第2ホログラム群とを重ね合わせた構造のホログラム、もしくは半径方向に全体傾向としては異なる特性を有して投影光をスクリーンの法線方向に変換し、微細エリアとしては1点集光または線集光の特性を有するホログラムなどを用いてもよい。

[0024] [第4実施形態] 次に、図10～図12を参照して、この発明に係わる透過型スクリーンの第4実施形態について説明する。この透過型スクリーンは、図10および図11に示すように、投影レンズ系などから広がり角度をもって投影された投影光を平行光線に変換する光学素子30と、光学素子30から出射された平行光線をスクリーンの法線34方向に変換するホログラム31と、このホログラム31の出射面に張り合わせた拡散板32とから構成されている。光学素子30は、その入射面にフレネルレンズ30aが形成され、出射面にリニアプリズムレンズ30bが形成され、フレネルレンズ30aによって広がり角度をもった投影光を光軸33に平行な光線に変換し、この光軸をリニアプリズムレンズ30bによってホログラム31に一定の入射角θで入射させる構造になっている。すなわち、このリニアプリズムレンズ30bは、ライン状のマイクロプリズムを上下方向に配列形成し、フレネルレンズ30aで変換された光軸33に平行な光線を各マイクロプリズムで斜め上方に向けて平行に出射する構造になっている。

[0025] ホログラム31は、回折効率の波長選択性がないか、若しくは少ないもので、1つの回折格子で平行な投影光のいずれの波長も回折するとともに、波長に応じて異なる回折角で回折し、平行な投影光をスクリーン(ホログラム31)の法線方向に変換して出射する構造になっている。すなわち、このホログラム31は、回折格子が水平方向に延びて上下方向に一定のピッチで配列形成され、1つの回折格子で平行な投影光を赤、緑、青の3種類の波長成分に分光してスクリーンの法線方向に向けて出射する構造になっている。このホログラム31の特性は、図12に示すように、全体的に短辺方向の位置に対してほぼ平行で、各回折格子ごとでギザギザ状態となる特性を有している。拡散板32は、透明な樹脂またはガラスに拡散剤を混入して入射した光を拡散させるものであり、拡散性が低く抑えられて透過率が高く設定され、補助的に使用するようになっている。

[0026] このような透過型スクリーンでは、広がり

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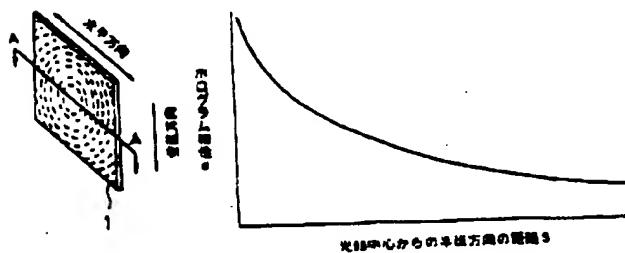
角度をもった投影光が光学素子30のフレネルレンズ30aに入射すると、このフレネルレンズ30aによって投影光を光軸33に平行な光線に変換し、この平行光線をリニアプリズムレンズ30bによって斜め上方に向けて出射させてホログラム31に一定の入射角θで入射させ、この入射した斜め上方に向かう平行な光線をホログラム31によって赤、緑、青の各波長成分に分光とともに、分光した光線をスクリーンの法線方向に変換し、この変換された光線を拡散板32によって拡散させることができる。このように、この透過型スクリーンでは、広がり角度をもった投影光を光学素子30で平行光線に変換し、この平行光線をホログラム31で各波長成分に分光してスクリーンの方線方向に変換しているので、拡散板32の拡散性を高くする必要がないため、拡散板32の透過率を高くすることができ、このため拡散板32を用いても、従来のものと比べて光の損失が少なくてすみ、光の利用効率が良く、鮮明な画像を得ることができ、しかも拡散板32を用いているので、視野角特性の向上も図れる。

【0027】なお、上記第4実施形態では、入射側にフレネルレンズ30aが形成され、出射側にリニアプリズムレンズ30bが形成された光学素子30を用いたが、これに限らず、光学素子をフレネルレンズのみで構成してもよい。この場合には、光軸33に平行な光線がホログラム31を垂直に入射するようにしてもよいが、ホログラム31を光軸33に対してテルトさせてよい。また、上記第4実施形態では、ホログラム31の出射面に拡散板32を設けたが、必ずしも拡散板を設ける必要はない。

【0028】

【発明の効果】以上説明したように、請求項1記載の発明によれば、広がり角度をもった投影光をスクリーンの法線方向に変換させるホログラムを備えたから、拡散フィルムなどの拡散板を用いなくても、広がり角度をもった投影光を損失することなく良好にスクリーンの法線方向に変換させて出射させることができ、このため光の利用効率が良く、鮮明な投影画像が得られる。また、請求

【図1】



【図4】

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項7記載の発明によれば、広がり角度をもった投影光を平行光線に変換する光学素子と、この光学素子から出射されて一定方向の入射角度で入射した光線をスクリーンの法線方向に分光集光するホログラムとを備えたから、光学素子により広がり角度をもった投影光を平行光線に変換してホログラムに入射させることができ、かつホログラムにより入射した光を損失することなくスクリーンの法線方向に分光集光させることができ、このため光の利用効率が良く、鮮明な投影画像が得られる。

10 【図面の簡単な説明】

【図1】この発明の透過型スクリーンの第1実施形態を示す斜視図。

【図2】図1のA-A拡大断面図。

【図3】図2のホログラムの原理図。

【図4】図2のホログラムの特性図。

【図5】半径方向に全体傾向としては異なる特性を有して投影光をスクリーンの法線方向に変換し、微細エリアとしては1点集光の特性を有するホログラムの特性図。

【図6】この発明の透過型スクリーンの第2実施形態を示す斜視図。

【図7】図5のB-B拡大断面図。

【図8】この発明の透過型スクリーンの第3実施形態を示す斜視図。

【図9】図8のC-C拡大断面図。

【図10】この発明の透過型スクリーンの第4実施形態を示す斜視図。

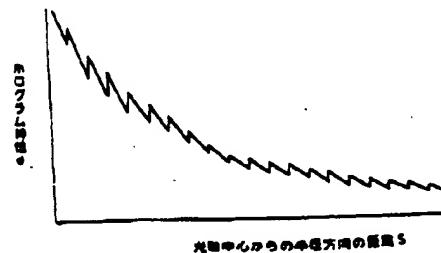
【図11】図10のD-D拡大断面図。

【図12】図11のホログラムの特性図。

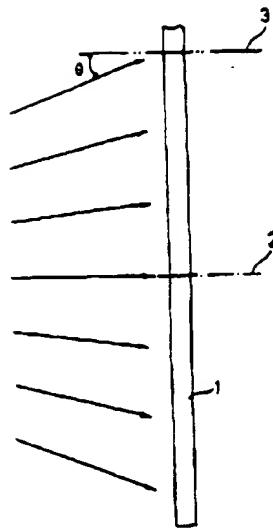
【符号の説明】

- 30 1. 10. 31 ホログラム
- 2. 13. 33 光軸
- 3. 14. 34 スクリーンの法線
- 11 第1ホログラム
- 12 第2ホログラム
- 30 光学素子
- 30a フレネルレンズ
- 30b リニアプリズムレンズ

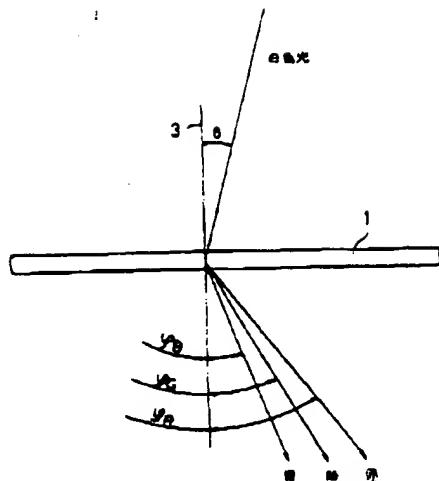
【図5】



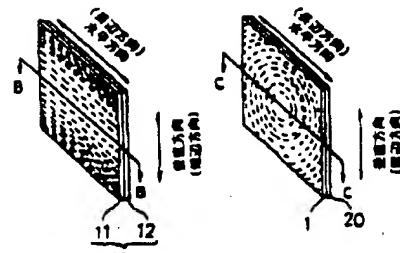
[图2]



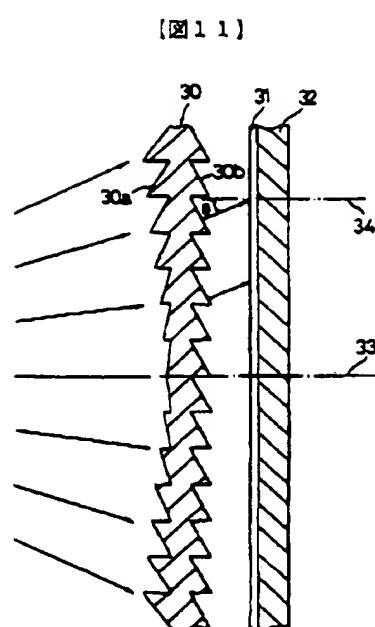
{图3}



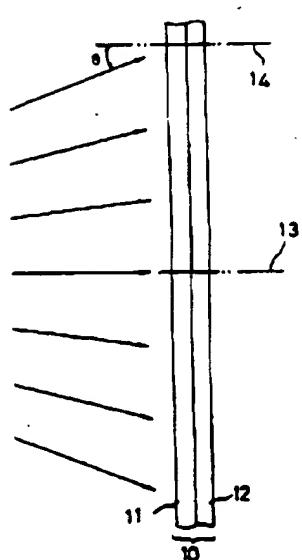
(図6)



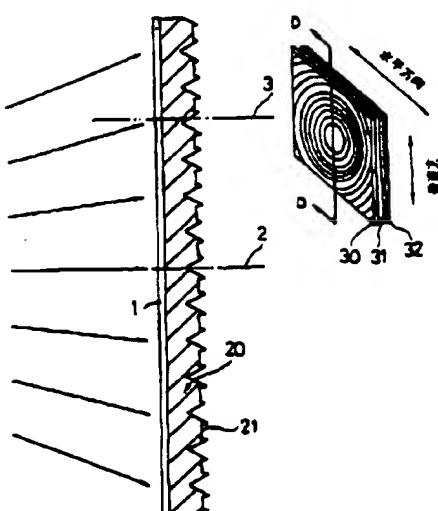
(图 8)



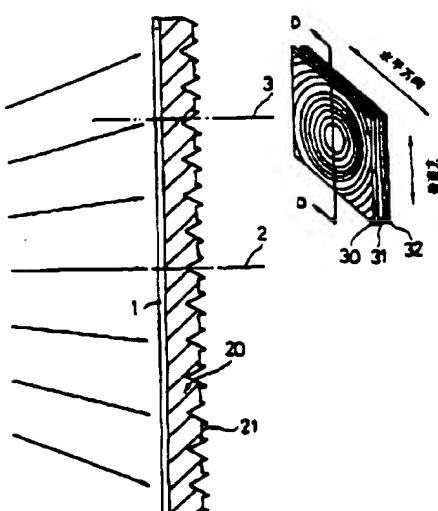
(图7)



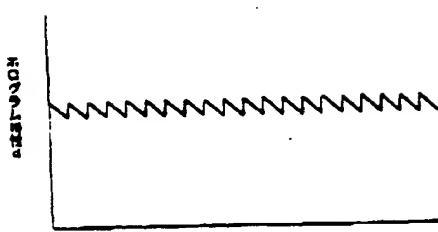
(図9)



(圖 10)



[图12]



辺境の民族の歴史

JP 9-73133/RCA 88698 PCT/DPF (MPM) /No. 4427

(19) Office of Patents, Government of Japan (JP)
(11) Patent Application Kokai (Laid Open) No. Toku Kai Hei 9-73133
(12) Kokai Patent Koho (Publication) (A)
(43) Kokai Date: March 18, 1997

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(51) Int. Cl.⁶ G 03 B 21/62, 21/56, G 03 H 1/22

Discrimination Code:

Intra-office Coordination No.

F1. Technology disclosure location

G 03 B 21/62, 21/56, G 03 H 1/22 Z

Request for Examination: Not filed as yet.

Number of Claims: Eight FD

(Total No. of Pages - Seven)

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(21) Application No. Toku Gan Hei 7-250058

(22) Date of Application: September 5, 1995

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(54) (Title of Invention) Screen of the Transmission Type

(57) (Summary)

(Task)

To obtain bright projection images at high efficiency of light utilization.

(Means for Solution)

A hologram is provided for the conversion of a projection beam having an expanded angle against the optical axis 2 in the direction of the normal line of the screen. This hologram 1 has either no or little wave-length selectivity having a property in the radius direction. It diffracts any wave-length of the projection beam with one

diffraction lattice, with said diffraction being carried out at different diffraction angles, depending upon the wave-length involved. Even without using such a diffusion plate as the diffusion film, etc., therefore, the projection beam having an expanded angle as compared with the optical axis 2 can be converted in the direction of the normal line of the screen satisfactorily without any loss, thereby making it possible for a bright and clear projection image to be obtained at a high rate of use efficiency.

(Insert the drawing on p. (1)..)

(Scope of Claims for Patent)

(Claim 1)

A screen of the transmission type which is characterized in that there is provided a hologram for the conversion of the projection beam having an expanding angle into the direction of the normal line of the screen.

(Claim 2)

A screen of the transmission type as described in Claim 1, characterized in that the said hologram has no or little wave-length selectivity having a different property in the radius direction.

(Claim 3)

A screen of the transmission type as described in Claim 1, characterized in that the said hologram has a structure in which three kinds of holograms having different properties in the radius direction and possessing the wave-length selectivity for each of the wave-length components of red, green and blue, are overlapped.

(Claim 4)

The said hologram has a structure in which the first hologram with either no or little wave-length selectivity having different properties in the vertical direction only in the direction from the center to the short side and the second hologram with either no or little wave-length selectivity having different property only in the horizontal direction in the direction from the said center to the long side are overlapped, one on top of the other, in a screen of the transmission type as described in Claim-1.

(Claim 5)

A screen of the transmission type as described in Claim 1, characterized in that same comprises a first hologram group that is obtained by overlapping three kinds of holograms having different property only in the vertical direction in the direction between the center and the short side and possessing wavelength selectivity for each of the wave-length components of red, green and blue and a second hologram group that is obtained by overlapping three kinds of holograms possessing different property only in the horizontal direction in the direction between the said center and the long side and having wavelength selectivity for each wave-length component of red, green and blue, one superimposed on top of the other.

(Claim 6)

A screen of the transmission type as described in Claim 1, characterized in that the said hologram has a different property as an over-all trend in the radius direction, converts the said projection beam into the direction of the normal line of the screen and has the properties of one-point condensing or linear condensing as a fine area.

(Claim 7)

A screen of the transmission type which is characterized in that it comprises an optical element for the conversion of a projection beam having an expanding angle into parallel beams and a hologram for the spectral condensing of the beam that has entered at the incident angle in a certain fixed direction as it is emitted from this optical element in the direction of the normal line of the screen.

(Claim 8)

A screen of the transmission type as described in Claim 7, characterized in that the said optical element is either a fresnel lens or a combination of a fresnel lens and a linear prism lens.

(Detailed Explanation of the Invention)

(0001)

(Technical Field to Which the Invention Belongs)

This invention relates to the screen of the transmission type.

(0002)

(Technology According to Prior Art)

The screens on which images are projected by a projection lens include the screen of the reflection type whereby a projected image is observed from the side of the projection lens and the screen of the transmission type whereby a projected image is observed from the side which is opposite to the projection lens.

Here, the screen of the transmission type will be explained. This screen of the transmission type ordinarily consists of such a diffusion plate as a diffusion film, etc. and a projected beam having an expanding angle is caused to enter into this diffusion plate from the projection lens, with the beam that has been entered being diffused by a diffusion plate for output.

(0003)

(Problem to be Solved by the Invention)

In the case of such a screen of the transmission type, however, diffusibility comes down when the transmission rate of the diffusion plate rises and, on the other hand, the rate of transmission comes down when the diffusibility rises, with a result that there is a loss of light, thereby making it impossible to obtain a clear projection image.

The task of this invention, therefore, lies in the acquisition of a clear projection image with the use efficiency of light on a high level.

(0004)

(Means for Solving the Problem)

Inasmuch as the invention described in Claim 1 is equipped with a hologram for the conversion of a projection beam having an expanding angle into the direction of the normal line of the screen, the projection beam having an expanding angle can be converted in the direction of the normal line of the screen satisfactorily without any loss, with a result that the use efficiency of light is high and that a clear projection image can thus be obtained.

(0005)

If the hologram has no or little wave-length selectivity having different characteristics in the radius direction, the projection beam can be separated for each wave-length component as is described in Claim 2.

If the hologram has a structure in which three kinds of holograms having wave-length selectivity for each of the wave-length components of red, green and blue are overlapped, the projection beam having an expanding angle can be separated for each wave-length component to be emitted in the direction of the normal line of the screen.

(0006)

If the hologram has a structure having a first hologram having no or little wave-length selectivity having different property only in the vertical direction in the direction from the center to the short side and a second hologram having either no or little wave-length selectivity possesing different property in the horizontal

direction in the direction from the center to the long side, one superimposed on top of the other, as is described in Claim 4 or if the hologram has a structure possessing a first hologram group wherein three kinds of holograms having wave-length selectivity for each wave-length component of red, green and blue and possessing different property only in the vertical direction in the direction from the center to the short side and a second with three holograms having wave-length selectivity for each of the wave-length components of red, green and blue and having different property only in the horizontal direction in the direction from the center to the long side, one superimposed on top of the other, as is described in Claim 5, it becomes possible to color-separate the projection beam having an expanding angle for each wave-length component, followed by conversion in the horizontal direction and the vertical direction for output.

(0007)

If the hologram is such as will possess a different property as an over-all trend in the radius direction and converts the projection beam in the direction of the normal line of the screen and possess the characteristics of one-point condensing or linear condensing as a fine area as is described in Claim 6, moreover, it becomes possible to separate the light into various wave-length components as an over-all trend and condense the beams as a result of color separation as in the case of a micro-lens in a fine area.

(0008)

As the invention described in Claim 7 comprises an optical element for the conversion of the projection light

having an expanding angle into parallel beams and a hologram for the spectral condensing of the beam that has been emitted from this optical element and made incident at an incident angle in a certain direction in the direction of the normal line of the screen, it becomes possible to convert the projection beam having an expanding angle by the optical element into parallel beams to be made incident to the hologram and, moreover, spectrally condense the beam that has been entered by the hologram into the direction of the normal line of the screen without any loss, with a consequence that a clear projection image in which the use efficiency of light is high can be obtained.

(0009)

If, in this case, the optical element happens to be a fresnel lens as is described in Claim 8, the projection beam having an expanding angle can be made to enter the hologram approximately perpendicularly.

If, on the other hand, the optical element happens to be a combination of a fresnel lens and a linear prism lens, the projection beam can be converted in a direction which is approximately vertical to the hologram by the fresnel lens, with the said converted beam being caused to be incident to the hologram at an angle of incidence in a certain direction by the linear prism lens and the incident light being converted into the direction of the normal line of the screen by the hologram.

(0010)

(Forms of the Application of the Invention)

(First Form of Application)

The first example of a screen of the transmission type according to this invention will be explained below by referring to Figures 1 through 4. Figure 1 is an oblique view of the screen of the transmission type and Figure 2 is a cross section cut along line A-A in Figure 1. The screen of the transmission type comprises a hologram 1, where a projection beam that has been projected by a projection lens system etc. enters with an expanding angle against the optical axis 2.

This hologram 1 has either no or little wave-length selectivity having different property in the radius direction; it is constructed in such a way that diffraction is carried out at different diffraction angles in conformity with the wave-lengths, with the projection beam having an expanding angle being converted into a direction of the normal line of the screen for emitting.

For example, said hologram 1 is formed in such a way that the diffraction lattice is formed concentrically with the center of the hologram 1 or the position of the optical axis 2 as the center, with one diffraction lattice color-separating the projection beam into the wave-length components of red, green and blue as is shown in Figure 3 to be outputted in the direction of the normal line of the screen.

According to the principle chart shown in Figure 3, it is exited toward the side of the center as compared with the direction of the normal line. However, it is actually ejected in the direction of the normal line of the screen.

(0011)

In other words, the relation between the incident angle to this hologram and the hologram 1 satisfies the

following requirements when the incident angle against the normal line 3 of the screen (hologram 1) is expressed by (θ) , and, among the exit angles of the beams from the hologram 1, the exit angle of the light of the red wave-length component is expressed by $(\psi)_R$, the exit angle of the beam of the green wave-length component is expressed by $(\psi)_G$, the exit angle of the beam of the blue wave-length component is expressed by $(\psi)_B$, the wave-lengths of red, green and blue are expressed by $(\lambda)_R$, $(\lambda)_G$ and $(\lambda)_B$ respectively and the pitch of the diffraction lattice of the hologram 1 is expressed by d :

(Insert (1), (2) and (3) at the top in the right-hand column on p. (3).)

In addition, the features of this hologram 1 are such that, as the distance s in the radius direction becomes longer from the center of the hologram 1 (the position of the optical axis 2), the pitch d of the diffraction lattice becomes gradually smaller.

Accordingly, therefore, the light that has entered at an angle of incidence (θ) are color-separated into the various wave-length components of red, green and blue and the beams $(\lambda)_R$, $(\lambda)_G$ and $(\lambda)_B$ of the various wave-length components which have been color-separated are exited in the direction approximately of the normal line of the hologram 1 at the different exit angles of $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ in this hologram 1.

According to this hologram 1, moreover, the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the beams of the various wave-length components become larger on the outer peripheral side where the angle of incidence (θ) is large and, on the other hand, the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the beams of various wave-

length components become smaller in the vicinity of the optical axis 2 where the angle of incidence is small.

(0012)

When a projection light having an expanding angle enters the hologram 1 according to the screen of the transmission type, the projection light is color-separated into the various wave-length components of red, green and blue as is shown in Figure 3 and, at the same time, the beams of the various wave-length components that have been color-separated are exited approximately in the direction of the normal line of the screen (hologram 1).

At this time, since it is so arranged that the pitch d of the diffraction lattice may become smaller gradually along with an increase in the distance g in the radius direction from the center of the hologram 1 (the optical axis 2), the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the beams of various wave-length components become larger on the side of the outer periphery where the angle of incidence (θ) is large and, on the other hand, the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the beams of various wave-length components become smaller in the vicinity of the optical axis where the angle of incidence (θ) is small.

As a result of what has been described above, the beams of various wave-length components are exited approximately in the direction of the normal line of the screen (hologram 1). Therefore, the projection beams having an expanding angle can be converted into the direction of the normal line of the screen in a satisfactory manner for exit without any loss by the hologram 1.

As a consequence of what has been described above, it becomes possible to acquire a clear projection image with a high rate of light utilization.

(0013)

In the first example described above, a hologram 1 possessing either no or little wave-length selectivity having different properties in the radius direction was used. However, it is not limited to this. For example, its structure may be such that three kinds of holograms having the wave-length selectivity for each of the wave-length components of red, green and blue with the hologram having different properties in the radius direction may be overlapped.

In such a case, the projection light can be color-separated for each of the wave-length components of red, green and blue by the holograms that diffract in conformity with the wave-length components to be exited in the direction of the normal line of the screen. In this manner, too, exiting can be effected without a loss of the projection light and a clear projection image can be obtained at a high level of light utilization.

(0014)

Even though one diffraction lattice of the hologram 1 is formed circular in the first example that has been described above, it is not limited to this alone. It is possible to use a hologram having a structure in which one diffraction lattice is formed in the form of a zigzag circle and same is arranged and formed concentrically, thereby converting the said projection light into the direction of the normal line of the screen, with different properties as an over-all trend in the radius direction

and possessing the properties of the one-point condensing or linear condensing as the fine area. The pitch d of the diffraction lattice of this hologram is set in such a fashion that, as in the case of the first example, it may become smaller gradually in conformity with an increase in the distance to the radius direction from the center (optical axis).

The properties of such a hologram assume a mild curve as a whole from the left top to the right bottom as is shown in Figure 5. This curve has a property of assuming a zigzag form.

Even by employing such a hologram, the projection light having an expanding angle can be color-separated into the various wave-length components as an over-all trend and the color-separated light can be condensed as in the case of a micro-lens in a fine area which is in a zigzag form. Because of this, it becomes possible to eject the projection beam toward the direction of the normal line of the screen without a loss, thereby making it possible to obtain a clear projection image at a high level of light utilization.

(0015)

(Second Example)

Next, the second form of application of the transmission type screen according to this invention will be explained below by referring to Figures 6 and 7. This screen of the transmission type comprises a hologram 10 having a structure in which the first hologram 11 and the second hologram 12 are overlapped with each other. The projection light that has been projected by a projection lens system enters the hologram 10 in an

expanding angle.

(0016)

The first hologram 11 has either no or little wave-length selectivity having a different property only in the vertical direction in the direction (up and down direction) from its center (optical axis 3) to the short side. In other words, this first hologram 11 diffracts all wave-lengths of the projection beams with one diffraction lattice and, at the same time, diffracts at different diffraction angles in conformity with the wave-lengths.

Different from the first example, it has a structure in which the diffraction lattice extends in the horizontal direction along the long side, is arranged and formed in the up and down direction at a prescribed pitch d and converts the beams that expand in the vertical direction among those projection beams that have entered with an expanding angle into a horizontal direction (the direction of the normal line 14).

For example, this first hologram 11 is set up in such a fashion that color-separation can be effected into the various wave-length components of red, green and blue with one diffraction lattice and the pitch d of the diffraction lattice may become smaller in a gradual manner in conformity with an increase in the distance from the optical axis in the up and down direction. Because of what has been described above, the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the various wave-length components become smaller in the vicinity of the optical axis 13 where the angle of incidence (θ) is small and the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of

the beams of various wave-lengths may become larger on the side of the up and down side where the angle of incidence (theta) is large.

(0017)

In addition, the second hologram 12 has either no or little wave-length selectivity having different properties only in the horizontal direction in the direction from its center (optical axis 13) to the long side (right and left direction). In other words, this second hologram 12 (like the first hologram 11), diffracts any wave-length of the projection beam with one diffraction lattice and, at the same time, effects diffraction at different diffraction angles in conformity with the wave-lengths. Different from the first hologram 11, the diffraction lattice extends in the vertical direction along the short side, arranged in the right and left direction at a prescribed pitch d and converts the beam that expands in the horizontal direction, amongst those projection beams that have entered with an expanding angle, in the direction of the normal line.

For example, this second hologram 12 effects color separation into the various wave-length components of red, green and blue with one diffraction lattice and, at the same time, is so set that the pitch d of the diffraction lattice may become gradually smaller along with an increase in the distance from the optical axis 13 to the right and left direction. Because of this, the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the beams of various wave-length components become smaller in the vicinity of the optical axis 13 where the angle of incidence

(theta) is small and the exit angles $(\psi)_R$, $(\psi)_G$ and $(\psi)_B$ of the beams of various wave-length components become larger on the side of the right and left sides where the angle of incidence (theta) is large.

(0018)

According to such a screen of the transmission type, upon the incidence of a projection beam having an expanding angle against the optical axis 13 onto the first hologram 11, the projection light that expands in the up and down direction (vertical direction) is color-separated into the various wave-length components of red, green and blue to be exited toward the direction of the normal line (horizontal direction) of the screen, with the projection beams that expand in the horizontal direction passing the first hologram 11 as they are.

When the projection beam that has passed the first hologram 11 enters the second hologram 12, the projection beam that expands in the right and left direction (horizontal direction) are color-separated into the various wave-length components of red, green and blue by the said second hologram 12, with the projection beams in the up and down direction (vertical direction) being transmitted through the second hologram 12 as they are.

Accordingly, the projection beam with an expanding angle that has entered into the hologram 10 is color-separated into the various wave-length components of red, green and blue by the first hologram 11 and the second hologram 12 and is converted into the horizontal direction and the vertical direction to be exited in the direction of the normal line of the screen. As in the case of the first sample, therefore, the projection beam having an expanding angle can be satisfactorily exited in the direction of the normal line of the screen.

without any loss. Because of this, a clear projection image can be obtained at a high level of light utilization.

(0019)

In the above second form of application (second example), a hologram 10 having a structure in which the first hologram having either no or little wave-length selectivity having different properties in the vertical direction only in the direction from the center (optical axis 13) to the short side and the second hologram having either no or little wave-length selectivity with different properties only in the horizontal direction in the direction from the center (optical axis 13) to the long side are superimposed one on top of the other was used.

However, it is not limited to this alone. For example, it is possible to use a hologram having a structure in which the first hologram group where three kinds of holograms having wave-length selectivity for the wave-length components of red, green and blue and possessing different properties only in the vertical direction in the direction from the center to the short side are piled and the second hologram group where three kinds of holograms possessing different properties only in the horizontal direction in the direction from the center to the long side and having the wave-length selectivity for each of the wave-length components of red, green and blue are piled are superimposed one on top of the other.

Even in the manner described above, the projection light can be color-separated for each of the wave-length components of red, green and blue, same is converted in

the vertical direction and the horizontal direction and can be exited in the direction of the normal line of the screen by the first hologram group and the second hologram group, thereby making it possible for the projection light to be exited without any loss. Therefore, it becomes possible to obtain a clear projection image at a high level of light utilization.

(0020)

(Third Example)

Next, the third form of application of the screen of the transmission type according to this invention will be explained below by referring to Figures 8 and 9. It is mentioned in this connection that those parts which are the same as in the first example that is shown in Figures 1 through 4 are given the same codes and their explanations will be omitted.

This screen of the transmission type comprises a hologram 1 and a diffusion wrench 20 as is shown in Figures 8 and 9, in which the hologram 1 is arranged on the incident side of the projection light having an expanding angle against the optical axis 2, with the diffusion wrench 20 being arranged on the exit side. In this case, the hologram 1 has exactly the same structure as in the first example.

The diffusion wrench 20 is formed with a transparent resin film or a transparent resin board, with a lenticular lens 21 being arranged on its exit surface in the horizontal direction, with the said lenticular lens 21 serving the purpose of condensing the beams of the various wave-length components of red, green and blue that expand in the horizontal direction.

(0021)

In the case of such a screen of the transmission type, if a projection beam having an expanding angle enters the hologram 1, the various wave-length components of red, green and blue are color-separated by the hologram 1 and the beams of the various wave-length components that have been color-separated are converted into the direction of the normal line of the screen for exit, the beams that have been exited enter the diffusion wrench 20 and the beam that expands in the horizontal direction amongst the beams that have been color-separated into the various wave-length components of red, green and blue by the lenticular lens 21 of this diffusion wrench 20 is condensed.

Because of what has been described above, the projection beam having an expanding angle is converted into the direction of the normal line of the screen as in the case of the first form of application, with a result that the projection light can be exited in the direction of the normal line of the screen without any loss whatsoever. In addition, since the beam that expands in the horizontal direction amongst those beams that have been exited from the hologram 1 is condensed by the diffusion wrench 20, it becomes possible to let the projection beam have a sight range angle, thereby improving the sight range angle properties.

(0022)

In the third example described above, a lenticular lens 21 was arranged and formed on the exit surface of the diffusion wrench 20 in the horizontal direction. However, it is not limited to this alone. It is also possible

to arrange and form the lenticular lens 21 in the vertical direction, thereby condensing the light that expands in the up and down direction.

In the third example, moreover, a diffusion wrench 20 having a lenticular lens 21 was used. However, it is not limited to this alone. It is also possible to use such a diffusion plate as a diffusion film etc. In such a case, since the projection light is converted into the direction of the normal line of the screen by the hologram 1, it becomes possible to use a diffusion plate with a high transmission rate, where the diffusibility is controlled low.

As a result of the above, as the rate of transmission is high in the case where such a diffusion plate has been employed, the loss of light will be small even if a lenticular lens may be formed on its exit surface as in the case of the third example.

(0023)

In addition, the said third example was explained in the case where a hologram 1 having a structure which is exactly the same as in the first example was used. However, it is not limited to this alone. For example, a hologram having a structure in which three kinds of holograms having different properties in the radius direction and possessing wave-length selectivity for each of the wave-length components of red, green and blue are piled up, a hologram having a structure in which a first hologram group in which three kinds of holograms having different properties only in the vertical direction in the direction from the center to the short side and possessing wave-length selectivity for each of the wave-length components of red, green

and blue are piled up and a second hologram group in which three kinds of holograms having different properties in the horizontal direction in the direction from the center to the long side and possessing wave-length selectivity for each of the wave-length components of red, green and blue are piled up, a hologram having the same structure as in the second example, or a hologram having different properties in the radius direction as an over-all trend, with the ptojection beam being converted in the direction of the normal line of the screen and possessing the properties of one-point condensing or linear condensing as a fine area, etc. can be employed.

(0024)

(Fourth Example)

Next, the fourth form of application of the screen of the transmission type according to this invention will be explained by referring to Figures 10 through 12. As is shown in Figures 10 and 11, this transmission type screen comprises an optieal system 30 for converting the projection light that has been projected from a projection lens system, etc. with an expanding angle into parallel beams, a hologram 31 for converting the parallel beams that have been exited from the optical element 30 into the direction of the normal line of the screen and a diffusion plate 32 that has been pasted to the exit surface of this hologram 31.

The optical element 30 has a fresnel lens 30a formed on its incident surface and a linear prism lens

30b on the exit surface, with the projection beam having an expanding angle being converted into a beam which is in parallel with the optical axis 33 by the fresnel lens 30a and this beam is entered into the hologram 31 at a certain angle (θ) of incidence by the linear prism lens 30b.

In other words, this linear prism lens 30b has a structure in which a micro prism which is in a linear shape is arranged and formed in the up and down direction and a beam which is in parallel with the optical axis 33 as converted by the fresnel lens 30a is exited in parallel in an obliquely upward direction by each micro-prism.

(0025)

The hologram 31 has either no or little wave-length selectivity of the diffraction efficiency; it diffracts any of the wave-lengths of the projection beams in parallel with one single diffraction lattice and, at the same time, diffracts at a different diffraction angle in conformity with the wave-length, thereby converting the parallel projection beams into the direction of the normal line of the screen (hologram 31).

According to this hologram 31, the diffraction lattice extends in the horizontal direction and is formed and arranged in the up and down direction at a certain pitch d , thereby color-separating the projection beams in parallel into the three different wave-length components of red, green and blue with one diffraction lattice to be exited toward the direction of the normal line of the screen.

As is shown in Figure 12, the properties of this holo-

gram 31 are such that it is approximately in parallel with the position in the direction of the short side as a whole, with a zigzag state being assumed for each diffraction lattice.

The diffusion plate 32 is prepared by mixing a diffusion agent with either transparent resin or glass, thereby diffusing the beam that has entered. Its diffusibility is held low, its rate of transmission is set high for auxiliary use.

(0026)

According to the screen of the transmission type as described above, upon the incidence of a projection beam having an expanding angle into the fresnel lens 30a of the optical element 30, the projection beam is converted into a beam which is in parallel with the optical axis 33 by this fresnel lens 30a and is exited in an obliquely upward direction by means of a linear prism lens 30b, and it is entered into the hologram 31 at a certain angle (theta) of incidence and the parallel beam facing obliquely upward that has been entered is color-separated into the various wave-length components of red, green and blue by the hologram 31 and, at the same time, the beam that has been color-separated is converted into the direction of the normal line of the screen and this converted beam is diffused by the diffusion plate 32.

According to the screen of the transmission type, a projection beam having an expanding angle is converted into parallel beams with an optical element 30, this parallel beam is color-separated into the various wave-length components by the hologram 31 into the direction

of the normal line of the screen, with a result that there is no need to raise the diffusibility of the diffusion plate 32. Therefore, it becomes possible to elevate the transmission rate of the diffusion plate 32. Because of this, the loss of light can remain small as compared with the earlier product even when the diffusion plate 32 is used. Thus, it becomes possible to obtain a clear image at a high level of light utilization and, as the diffusion plate is used, an improvement is made possible in the range-of-sight angle properties.

(0027)

In the fourth example described above, an optical element 30 having a fresnel lens 30a formed on the side of incidence and a linear prism lens 30b formed on the exit side was used. However, it is not limited to this. For example, the optical element can be constituted by the fresnel lens alone. In such a case, it may be so arranged that a beam which is in parallel with the optical axis 33 enters the hologram vertically or the hologram 31 may be tilted as compared with the optical axis 33.

Moreover, a diffusion plate 32 was provided on the exit surface of the hologram 31 in the four example described above. However, there is not necessarily any need to provide a diffusion plate.

(0028)

(Effect of the Invention)

As has been described above, a hologram for converting a projection beam having an expanding angle into the direction of the normal line of the screen has been provided according to the invention described in Claim 1,

with a consequence that, even without such a diffusion plate as the diffusion film, etc., the projection beam having an expanding angle can be converted into the direction of the normal line of the screen in a satisfactory manner without a loss for exit. Because of this, a clear projection image is obtained at a high level of light utilization according to the invention described in Claim 1.

According to the invention described in Claim 7, moreover, an optical element for the conversion of a projection beam having an expanding angle into parallel beams and a hologram for the spectral condensing of the beam that has entered at an angle of incidence in a certain direction as it is exited from this optical element are provided, with a result that the projection beam having an expanding angle can be converted into parallel beams by the optical element to be made incident to the hologram.

In addition, the beam that has entered from the hologram can be spectrally condensed in the direction of the normal line of the screen without a loss. As a result of this, a clear projection image can be obtained at a high level of light utilization.

(Concise Explanation of the Drawings)

(Figure 1)

This is an oblique view showing the first example of a screen of the transmission type according to this invention.

(Figure 2)

This is a cross section cut along line A-A in Figure 1.

(Figure 3)

This shows the principle governing the hologram shown in Figure 2.

(Figure 4)

This shows the characteristics of the hologram shown in Figure 2.

(Figure 5)

This shows the characteristics of the hologram having different properties in the radius direction as an over-all trend, with the projection beam being converted into the direction of the normal line of the screen and having the properties of one-point condensing as a fine area.

(Figure 6)

This is an oblique view of the second example of a screen of the transmission type according to this invention.

(Figure 7)

This is a cross section cut along line B-B in Figure 5.

(Figure 8)

This is an oblique view of the third example of the screen of the transmission type according to this invention.

(Figure 9)

This is an expanded cross section cut along line C-C in Figure 8:

(Figure 10)

This is an oblique view showing the fourth example of the screen of the transmission type according to this invention.

(Figure 11)

This is an expanded cross section cut along line D-D in Figure 10.

(Figure 12)

This shows the characteristics of the hologram.

(Explanation of the Codes Used)

1, 10, 31. Holograms

2, 13, 33. Optical axes

3, 14, 34. Normal lines of the screen

11. First hologram

12. Second hologram

30. Optical element

30a. Fresnel lens

30b. Linear prism lens

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(Insert Figure 1 on p. (6). a. Horizontal direction. b. Vertical direction.)

(Insert Figure 2 on p. (7).)

(Insert Figure 3 on p. (7). a. (Translator's Note: Illegible). b. (Translator's Note: Illegible except) component. c. (Translator's Note: illegible except) component. d. (Translator's Note: illegible except) component.)

(Insert Figure 4 on p. (6). c. (Translator's Note: Unclear but look like) Hologram characteristics. d. Distance S in the radius direction from the center of the optical axis.)

(Insert Figure 5 on p. (6). e. (Translator's Note: Unclear but look like) Hologram characteristics. f. Distance S in the radius direction from the center of the optical axis.)

(Insert Figure 6 on p. (7). a. (Direction of the long side) Horizontal direction. b. Vertical direction (Direction of the short side).)

(Insert Figure 7 on p. (7).)

(Insert Figure 8 on p. (7). c. (Direction of the long side) Horizontal direction. d. Vertical direction (Direction of the short side).)

(Insert Figure 9 on p. (7).)

(Insert Figure 10 on p. (7). a. Horizontal direction. b. Vertical ... (Translator's Note: one character is illegible).)

(Insert Figure 11 on p. (7).)

(Insert Figure 12 on p. (7). c. Hologram characteristics. d. Position of the ... (Translator's Note: four characters are illegible except) ... direction (at the center).)